

what is the **SCIENCE CITATION INDEX**

the need

Every research scientist has, on one occasion or another, been stumped by the complex problems of searching the maze of accumulating scientific literature.

Once upon a time he considered it adequate to depend upon classically organized indexing systems.

For today's complex search requirements, traditional methods have distinct disadvantages and limitations. In this modern era, modern techniques of documentation are needed to lead the scientist out of his dilemma.

The INSTITUTE FOR SCIENTIFIC INFORMATION believes the SCIENCE CITATION INDEX is the practical solution.

versus conventional systems

The SCIENCE CITATION INDEX is a dynamic information system which not only makes straightforward, up-to-date literature searching practical, but also stimulates the process of information discovery.

It provides a variety of features beyond the scope and power of conventional indexing systems which cannot cope with the increasing welter of data erupting from modern poolings of scientific talent.

This disturbing mass of information, accentuated by the burgeoning of new specialties has all but paralyzed conventional techniques.

Paradoxically, this same prodigious growth of knowledge is the vital force of the SCIENCE CITATION INDEX method.

Indeed, the SCIENCE CITATION INDEX developed by the INSTITUTE FOR SCIENTIFIC INFORMATION is a self-organizing system which thrives on a growing literature.

It is an orderly arrangement that improves qualitatively as the quantitative character of the literature changes, constantly adding to, modifying and developing itself.

A living, growing system is achieved that rescues much of what is otherwise destined to become debris, lost and forever useless, and turns it into more meaningful, retrievable knowledge.

the method: concept and indexing

To appreciate the SCIENCE CITATION INDEX method, two major points must be emphasized and clearly understood: the basic concept and the basic indexing technique.

The SCIENCE CITATION INDEX idea is founded upon the pragmatic philosophy—"what has happened since?"—*WHAT* has a man published and precisely *WHO* and *WHERE* in any field of endeavor, has cited *ANY* of his works following its publication. We believe this is fundamental to research activity — to the scientific method. In short, SCIENCE CITATION INDEX is founded on an *a posteriori* concept.

Dr. Eugene Garfield, Director of THE INSTITUTE, has pointed out "the 'logic' of all conventional scientific classifications has inevitably broken down with experience. Aristotelian logic has been a chain around the neck of the scientist and classifier alike. If the old rigid classifications

are eliminated, the problems of changing terminology and the other inherent limitations of *a priori* indexing can be solved."

Thus, in creating the SCIENCE CITATION INDEX, the familiar hierarchal classifications, often illogical and non-specific to the scientist, are discarded. Because the scientist is usually aware of a particular work applicable to his specialized interests, he would begin a search in the SCIENCE CITATION INDEX with a specific paper.

In conventional language-oriented indexing systems, this is impossible.

The SCIENCE CITATION INDEX thus introduces a new technique of indexing and searching. It provides the scientist with an improved starting point: the *specific work* of a *specific author* at a *specific time* and *location*—author, year, journal, volume and page . . . and from there the searcher is *brought forward in time* to subsequent papers relating to the earlier paper.

The SCIENCE CITATION INDEX lists the reference (cited) author and his work, and with it, groups together all source (citing) authors and papers, who have referred to that same work since its publication. Each of the author's cited works, accompanied by its citing authors, is arranged chronologically.

As rapidly as they become cited, the SCIENCE CITATION INDEX continues to add new works of an author and/or new citation listings to his previously recorded papers.

The result of this process is a comprehensive, interdisciplinary, elastic index which is always up-to-date and encompasses the entire scope of scientific literature.

for example . . .

Consider Dr. Joshua Lederberg's article, "Genes and Antibodies", published in *Science* 129, 1649, (1959). The SCIENCE CITATION INDEX shows that in 1961 alone, this paper was cited in 26 papers.

Thus, the researcher, interested in following developments since the publication of this particular work could instantly identify a core of scientists whose work is related to Lederberg's article in *Science*, but had published in journals covering subjects from cancer research to space science.

Furthermore, the researcher could find listed under Lederberg's name, 59 additional works by him, published between 1946 and 1961, each together with its own group of citing articles.

result: brings the user "forward in time"

Now for the first time in the indexing of science literature, the researcher is brought forward in time to the most recent published work referring to a particular paper.

Conventional indexing systems lead the user to the past only, showing who has preceded, rather than who has followed an author.

Still, in the SCIENCE CITATION INDEX, the searcher can, if he chooses, go similarly backward in time, and compile additional material either by consulting bibliographies appearing in the various citing works or earlier papers of the same author listed in the SCIENCE CITATION INDEX.

This technique of "cycling" traces a literature network which can satisfy a need not only for covering a research area in depth and for browsing, but also for keeping pace with developments in a chosen area of interest, reducing unintentional and unnecessary duplication of research.

result: "an association of ideas"

Further analyses define the interdisciplinary character of the SCIENCE CITATION INDEX and show that seemingly unrelated material is pulled together, cutting across the disciplinary lines implied by the journal title.

Because papers are collated on the basis of common citations, works that might never be brought together, by even highly sophisticated indexing, are routinely pulled to-

gether in the SCIENCE CITATION INDEX.

An interesting example is the unexpected citation relationship uncovered between C. H. Whitnah's paper in *J. Dairy Science* **42**, 227 (1959) and a paper by Albert Einstein, *Ann. Physik* **19**, 289 (1906). The apparently incongruous combination proves to be a legitimate reference to an equation used in calculating molecular dimensions and applied in a study of the physical properties of milk.

This same article by Einstein was cited in an article by V. V. Varadaiah, *J. Polymer Science* **46**, 528 (1960) in which Einstein's equation was used as a basis for calculations relating to the Flory universal constant, in the equation for intrinsic viscosity.

Yet in two other papers by P. H. Elworthy, one in 1959, *J. Chem. Soc.* p. 1951, and a 1961 paper *J. Pharm. Pharm.* **13**, 663, the Einstein equation was cited in a discussion of the size and shape of lecithin micelles.

Still again in a 1961 paper by K. Yagi, *Comp. Bioch.* **3**, 73, the Einstein equation is employed in the study of mechanical and colloidal properties of amoeba protoplasm.

S. G. Schultz in *J. Gen. Physiol.* **44**, 1189 (1961) conducted biophysical studies in which he used the Einstein viscosity equation and confirmed atomic dimensions compiled by L. Pauling.

The Einstein article well illustrates the utility of the SCIENCE CITATION INDEX in crossing scientific disciplines, in picking up isolated, seemingly unrelated bits of information buried in the literature.

result: a dynamic process

The SCIENCE CITATION INDEX is based on the axiom that every author is an "indexer"—that is, in effect, each time he provides a citation in his paper, he is indexing some aspect of his work and re-indexing the scientific literature.

The natural interplay of old and new upon each other is an indissoluble part of the SCIENCE CITATION INDEX. These constant additions and modifications in the SCIENCE CITATION INDEX are its source of dynamic power. In this aspect, the SCIENCE CITATION INDEX simulates the learning process, reflecting the increased and changed knowledge of contemporary science.

result: relates old and new

What is current? In the SCIENCE CITATION INDEX method there are no artificial time barriers.

Most conventional indexing services are limited to a relatively short and specific time period: the past six months or the past year.

In the SCIENCE CITATION INDEX, older, but still currently important information and more recent information come together naturally, as illustrated in the citations to Einstein's 1906 article by five contemporary writers. It is a time-binding device, relating antecedent *parent* discoveries with their subsequent descendant *offspring*.

result: no intellectual or language barriers

By eliminating arbitrary "subject" classifications, the SCIENCE CITATION INDEX eliminates intellectual indexing decisions by catalogers.

Compiled by a unique combination of machine and clerical process, there are none of the omissions, inconsistencies, ambiguities, errors or semantic confusions of language-oriented indexing.

Typographical errors and other errors existing in the literature and inevitably made by men and machines, are usually offset by redundancy in the literature itself—a valuable self-correcting feature.

result: better scientist-to-scientist communication

By arranging literature according to citational relationships, the SCIENCE CITATION INDEX offers a simplified, practical solution for rapidly tracing the development or current evaluation of an idea, method or discovery—and facilitating their evaluation.

Unfortunately, authors may not know what becomes of their work after it appears in print. Many are totally unaware of new insights, meanings and implications of their works revealed by their contemporaries.

Through the SCIENCE CITATION INDEX, the scientist can see which scientists are citing his works—using his methods or that of colleagues—modifying them, improving, criticizing, etc. Communication is thereby fostered, especially between researchers in different fields.

the GRINGAUZ CASE and the SCIENCE CITATION INDEX

A "letter to the editor" in *Science*, 136, 594 (1962), called attention to the fact that in 1960 Dr. K. Gringauz, a Soviet scientist, discovered the existence of a third radiation belt, at the altitude of 40,000 miles. The data were published in the February and April (1960) issues of *Proceedings of the Soviet Academy of Sciences (Dokl. Akad. Nauk SSSR)* 131, 1301 (1960); 135, 48 (1960). (The English translation issues appeared in July and September of 1960.) However, most American scientists working in the same field as Gringauz apparently remained unaware of the Soviet report because in 1961 it was announced that a third radiation belt (at the same altitude) had been discovered by the U. S. Explorer XII satellite, without making reference to the Gringauz paper.

The Gringauz case dramatically points out that American scientists sometimes are not aware of the latest Soviet research in their individual specialties. The SCIENCE CITATION INDEX promises to help avoid such blatant oversights.

Scientists interested in developments in the field of atmospheric radiation certainly would be familiar with the work of James Van Allen, the discoverer of the Van Allen radiation belts. Using a preliminary citation index file, under Van Allen's name, one could have quickly found the above mentioned reference by Gringauz, in which he cites Van Allen's paper. This Gringauz article also cites the detailed first Gringauz paper and discusses the Russian discovery of the third radiation belt in the first paragraph.

Thus, a two minute search, using only a preliminary file, starting from obvious entries, uncovered the key articles on the Soviet discovery. Had the index been available in 1960, scientists in government research could have been better informed on Soviet space research, and eliminated the information lag.

a comprehensive selective service

Although output can be as comprehensive as input, computer processes can also yield a selective citation index service suitable to any specific field or request.

other applications

Although the SCIENCE CITATION INDEX was originally designed to be used for simple, direct retrieval of scientific information, it can facilitate utilization of the literature for sociological and historical evaluations and applications including:

The evaluation of the impact of a paper, a man's total works, a journal, material published during specific time intervals, the works of students of specific teachers, works coming out of a university or department, work financially sponsored by a specific agency.

The SCIENCE CITATION INDEX may be used to good advantage in writing historical reviews and descriptions of the evolution of specific subjects.

It may be used to study journal utilizations, measuring literature habits of scientists, effectiveness of specific journals in reaching specific audiences, purchasing requirements of specific libraries, library's need for maintaining files of most-frequently requested reprints, utilization of literature of one country by another, impact of scientific discoveries and inventions on technological development.

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